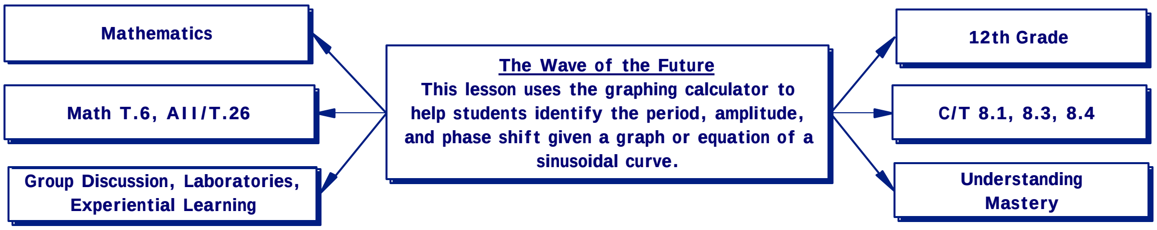


The Wave of the Future

Alvin Coleman
Deep Creek High School

Curriculum Area	Mathematics
Subject Area	Trigonometry/Sine Waves
Grade Level	12th grade
Learning Objectives	• The student will be able to identify the period, amplitude and phase shift given the graph or the equation of a sinusoidal curve. • The student will be able to sketch the graph of a sinusoidal curve given its equation in the form y = a sin k(s - d) or y = a cos k(s - d). • The student will be able to connect the study of sinusoidal curve with various scientific phenomena including the stretch of a spring. • The student will be able to write the equation of a sinusoidal curve given its graph.
Correlation to the SOL	Math T.6, AII/T.26 C/T 8.1, 8.3, 8.4
Video/Technology Hardware/Software Needed	**For class:** Computer connected to a printer Computer-Based Laboratory equipment and software TI-83 Graphing Calculator with Graph Link Videodisc Player or VCR with Monitor Overhead Projector Overhead screen for the TI-83 **For each group of 3-4 students:** Computer connected to printer Database software (such as *Microsoft Access* or *ClarisWorks*) **Videodisc or video:** Any clip of the Tacoma Narrows Bridge disaster
Materials Required	**For class:** 1 transparency of Trig Sketches Worksheet 1 1 transparency of Trig Sketches Worksheet 2 Overhead projector pens

	For each group of 3-4 students: 1 Vernier or CBR motion detector 1 ring stand 1 note card 1 spring 1 bit of tape 1 hook HOOK .82p (the TI-83 program which collects and graphs data from the CBL-ONLY). This is not needed for the CBR (programs can be downloaded from the CBR) **Per student:** Trig Sketches 1 worksheet Trig Sketches 2 worksheet TI-83 graphing calculator with link 1 piece of graph paper
Procedures/Activities	**Phase 1** 1. First, introduce the students to the idea that there are different types of sine curves, alluding to the idea that their appearance is predictable from the equation. 2. Have students enter the following equation into the graphing calculator: y = sin x y = 3 sin x y = -3 sin x Showing the graphs of these equations on the TI-83 overhead view screen as this discussion is underway makes them easier to talk about. What are the differences among the three graphs mentioned above? 3. Have students enter the following equations into the graphing calculator: y = sin 2x y = sin .5x Ask: What are the differences among the two graphs? This is difficult to describe without the word "period." Often it helps the students to imagine the graph of y= sin x to be a spring in resting position. Then they might say that the graph of y = sin 2x is a shrunken form of the graph of y = sin x and the graph of y = sin .5x is a stretched form of the graph of y = sin x. 4. Next, heighten the students' interest concerning the study of sinusoidal curves by using a dramatic sequence from a video or videodisc on the collapse of the Tacoma Narrows Bridge. Be sure to focus the students to watch for the events leading up to the collapse, and to listen for the comments people make about the collapse. A focus for the lesson the teacher asks, "Why did the Tacoma Narrows Bridge collapse?" Allow the class time to brainstorm some of their ideas. List these on the board. **Phase 2** 5. The class is now going to apply their knowledge of period, amplitude and phase shift to write the equations of the graphs of the set of sinusoidal curves in the attached worksheet, Trig Sketches 2. Have the class work in cooperative groups using their graphing calculators to write the equation of each curve. There are many equations which can be written twice, one with a phase shift and one without. Pick a paper from each group to assess the progress of the class. *Answers:*

with no phase shift	*with phase shift*
y = 2 cos (1/3)x	y = 2 sin (1/3) (x + 3??2)
y = -3 cos (1/4)x	y = -3 sin (1/4) (x + 2?)
y = 4 sin (1/3)x	y = 4 cos (1/3) (x - 3??2)
y = -2 sin (1/4)x	y = 2 cos (1/4) (x + 2?)
y = -2 sin (2/3)x	y = 2 cos (2/3) (x + 3??4)
y = 4 cos 3x	y = 4 sin 3 (x + ?6)
y = 3 sin 2x	y = - 3 cos 2 (x + ?4)
y = cos 2x	y = sin 2 (x + ?4)

6. This activity reverses activity one. The class will identify the period, amplitude and phase shift for each equation that follows. Check the answers before going further:
   y = - 3 sin (1/2) x
   (ans: amplitude = 3, period = 4? phase shift = 0)
   y = - sin (2/5) (x + ?)
   (ans. Amplitude = 1, period = 5? phase shift - left ? units)
   y = 2 sin (x - ?2)
   (ans. Amplitude = 2, period = 2? phase shift - right ?2 units)
   y = - 3 cos (1/3) (x + ?3)
   (ans. Amplitude = 3, period = 6? phase shift - left ?3 units)
   y = cos (x - 2?)
   (ans. Amplitude = .5, period = 2? phase shift - right 2? units)
   y = 2 cos 2 (x + 3??2)
   (ans. Amplitude = 2, period = phase shift - left 3??2 units)
7. After period, amplitude and phase shift have been identified correctly, have the class sketch the graphs of the preceding functions over one fundamental period. This would make a good independent practice assignment. Check student answers and answer questions before going further.

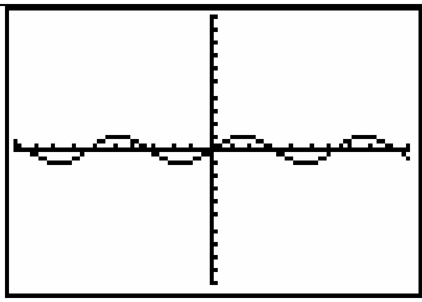
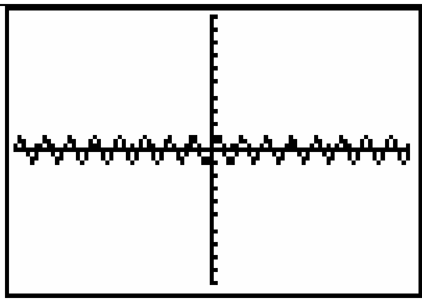
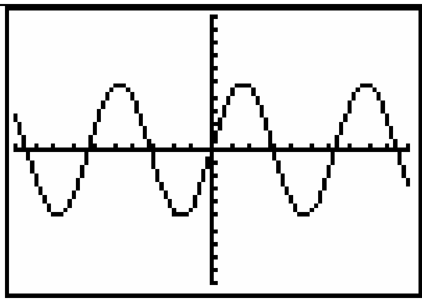
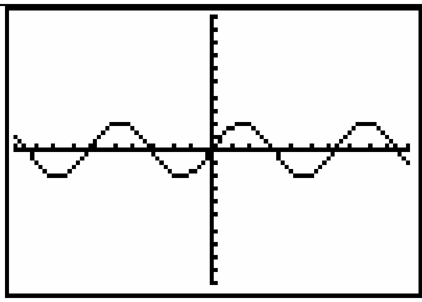
Phase 3

1. This experiment uses an oscillating model (a spring with various weights attached), a CBL plus probe, CBR, and a graphing calculator to generate the scatter plot of a slightly dampened sine curve. Note: The dampening characteristic will be more apparent using a spring that is quite tight. A loose spring that will bounce for a long time will be best for this activity. Students will have the opportunity to discuss periodicity, amplitude and phase shift using real world data that they have collected. This activity may be treated as a science lab with an appropriate lab report from each student to summarize and draw implications from the data.
2. Attach a spring to the ring on the ring stand and the weight to the bottom of the spring.
3. Attach the CBL or CBR unit to the TI-83 calculator with the link cable using the I/O ports on the bottom edge of each unit. Be sure the cables are pushed in firmly.
4. Connect the Vernier motion detector to the sonic port on the left side of the CBL unit, if CBR units are used then make sure the programs are download to the TI-83.
5. Place the motion detector on the floor directly beneath the spring. Tape the note card to the weight that is attached to the spring. This gives the motion detector a larger target. As the spring oscillates the note card should get no closer than 1.5 feet from the Vernier motion detector, in order to get good results.
6. Load the program Hook in the calculator. (CBL ONLY)
7. Turn on the CBL and the calculator.
8. Start the program HOOK on the TI-83.

	9. Carefully pull down the weight that is attached to the spring and then release it and allow it to oscillate. Once the motion has stabilized to being only in the vertical plane, press the trigger on the CBL. 10. When the graph appears, trace the scatter plot noting the x and y values. Note: Using the TI-83 Graph Link attached to a computer and printer the students can print copies of their scatter plots to include in the lab report. 11. Using the trace function find two consecutive maximums. Subtract the corresponding x-coordinates. This will give the period of the sine wave. 12. Using the trace function find the coordinate of a successive maximum and minimum. Subtract the y-coordinates. One half of this value is the amplitude. 13. Make an educated guess at what the phase shift might be. 14. Use the guess along with the results of steps 11 and l2 to write the equation of the sine wave generated from this data. 15. Enter the guess into the y= menu of the calculator to test if it will overlay the scatter plot. 16. Record the equation that best fits your data for the first two cycles. 17. Repeat steps 7-15 with a different weight.
Content Assessment	The worksheets serve as an effective evaluation.
Technology Integration Assessment	Observation of the students as they work on their data collection.
Extensions	**Science:** Have student investigate measures taken to avoid a repeat of the Tacoma Narrows Bridge disaster. Students can brainstorm other practical applications for the study of the sin waves.

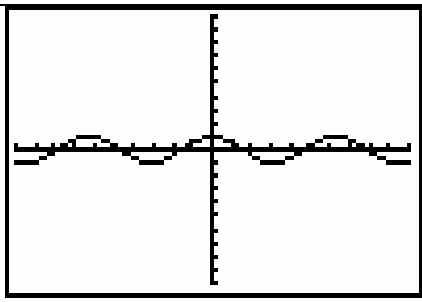
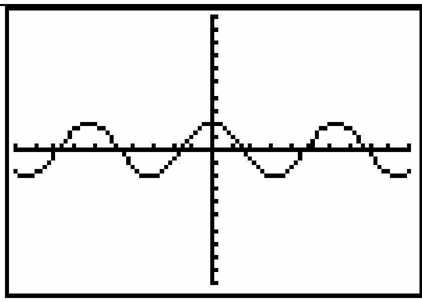
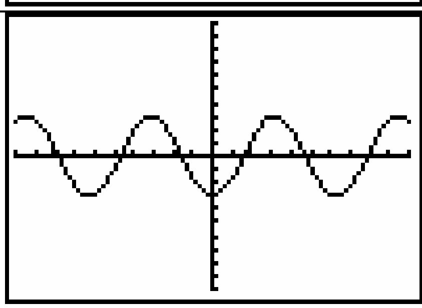
Trig Work Sheet #1
y = sin x

Match the equation with the correct Function:

	y = 5 sin x
	Y = sin x
	Y = sin5x
	Y = 2 sin x

Trig Work Sheet #2
y = cos x

Match the following equations with the correct graph:

	A. y = 2 cos x
	B. y = - 3 cos x
	C. C. y = 4 cos x